Note on the TITANIFEROUS IRON ORE BELT, *near Greensboro, North Carolina.*

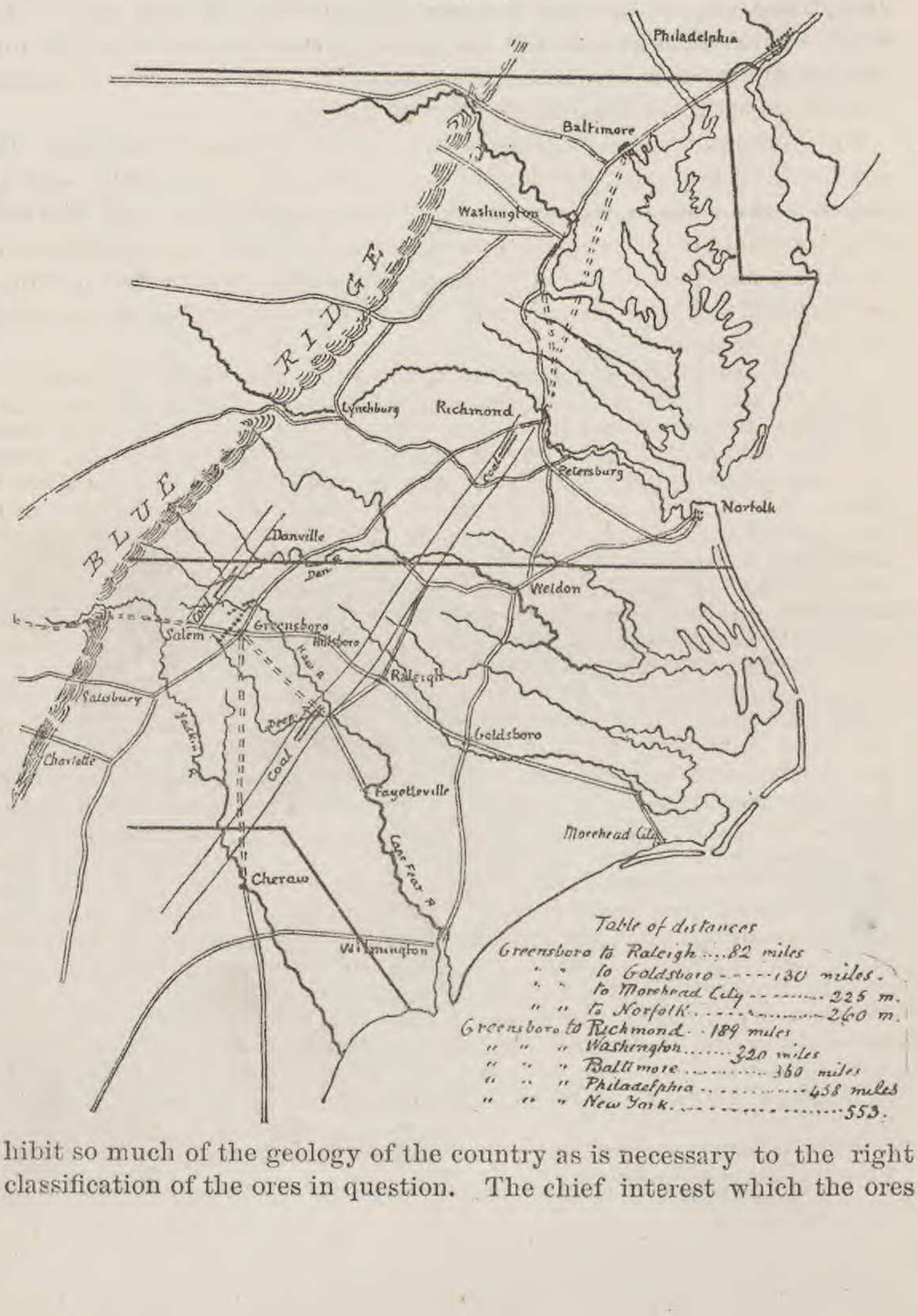
By J. P. LESLEY.

(*Read before the American Philosophical Society, June* 16, 1871).

I embrace the oportunity to exhibit the structure of this interesting ore belt, afforded by a recent survey of the lands through which it runs for thirty miles; lands owned or leased, by an association of gentlemen, known as the North Carolina Centre Iron and Manufacturing Company of Philadelphia, of which Mr. Thomas Graham is President.

The photolithographed cuts at my command, were reduced in fac simile, from my drawings, by Bien's process, and are sufficiently clear to ex-

FIG. 1.



hibit so much of the geology of the country as is necessary to the right classification of the ores in question. The chief interest which the ores have for us, comes from the analyses given below. But the relations which these ores bear to other ores of similar composition, cannot be understood without a general description of the district.

Fig. 1, will inform those who are not acquainted with American geography, of the geographical relationship of the Greensboro district to the Atlantic sea-board and to the Blue Ridge Range of Primary mountains.

The two Triassic belts containing coal appear on this map ; the eastern including the Richmond Coal Basin and that of Deep River ; the western that of Dan River, prolonged northward across the James River below Lynchburg, and originally connected with the continuous out-spread of the Trias in Maryland, Pennsylvania, New Jersey, and the Connecticut Valley.

Fig. 2 gives, on a larger scale, the position of the ore-belt in Guilford and Rockingham Counties, N. C., and the radiation of railways, already running, or under survey, from Greensboro.

FIG. 2.

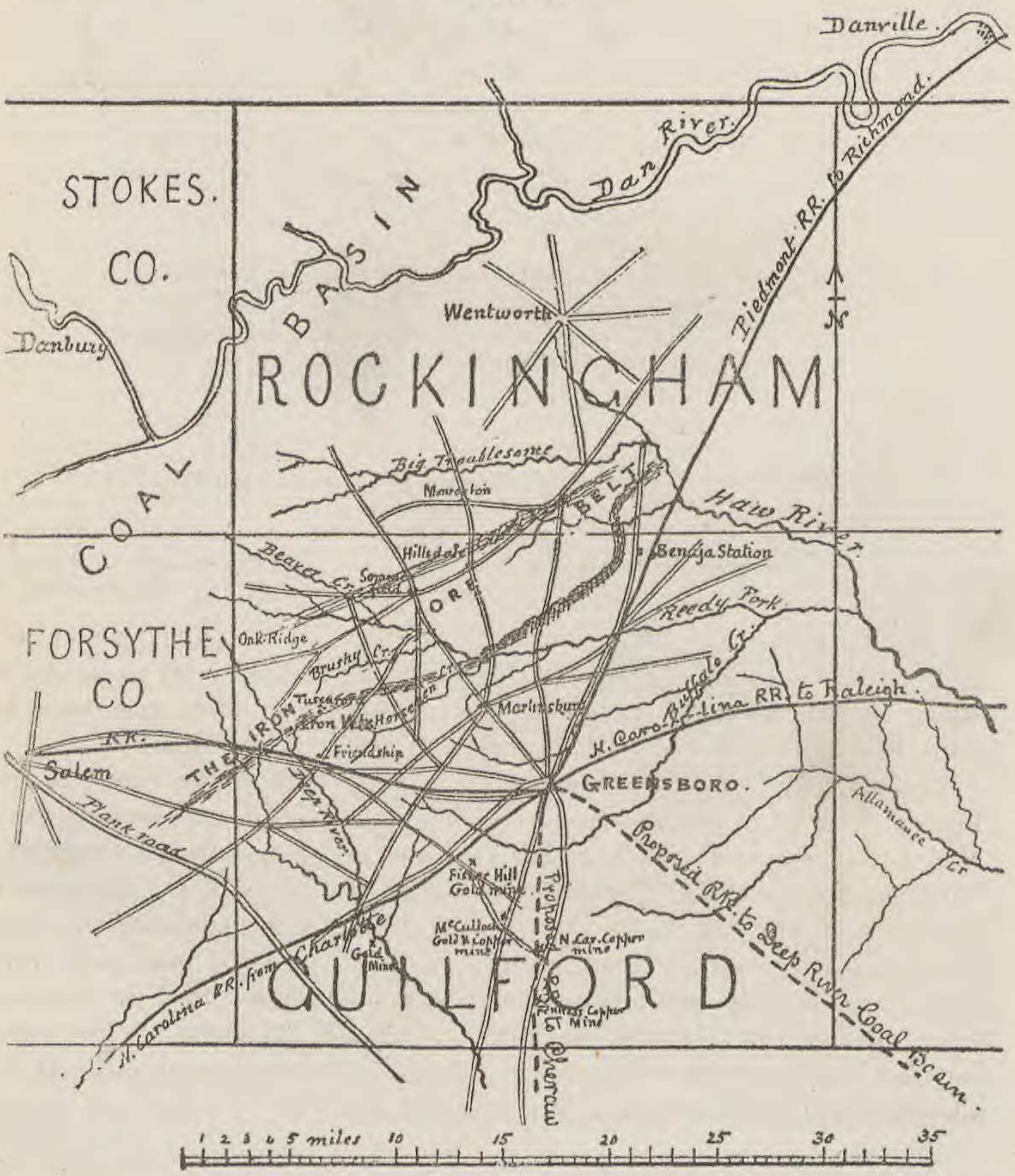
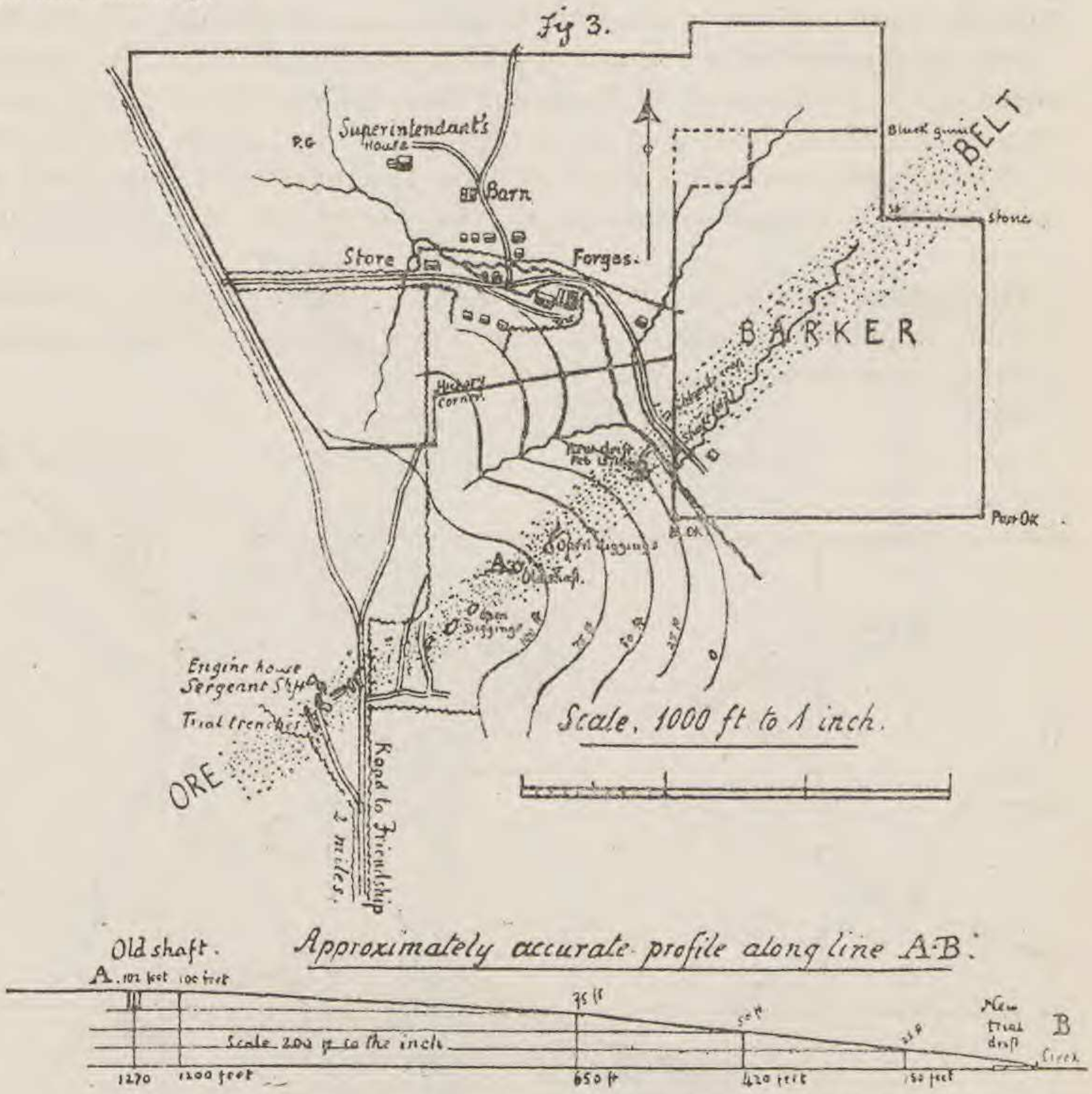


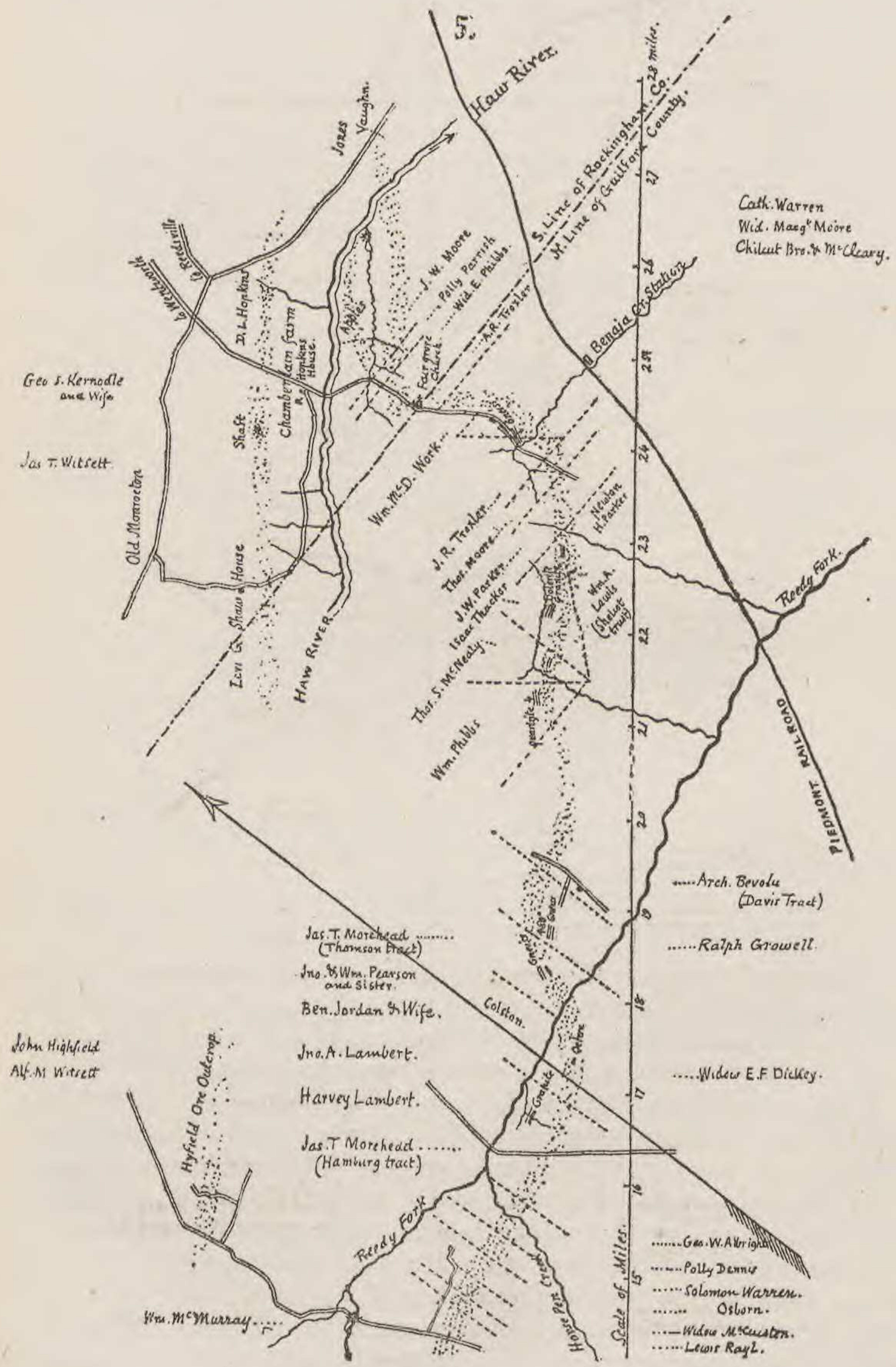
Fig. 3 is a special map of the ore-belt where it passes the Tuscarora forges, and has been most thoroughly tested. Here is the Sergeant shaft. The accompanying section will be of use, as it furnishes a carefully measured example of the numerous hill slopes which compose the surface of the country.



Figs. 4 and 5 continue the mapping of the ore-belt on to the head-waters of Deep River, to the southwest; and to the northeast as far as the Haw River. The general straightness of the outcrop for 15 miles, and more, is remarkable. The whole length surveyed was about 30 miles.

This part of North Carolina is occupied by some of the oldest rocks known; the same rocks which hold the iron ore-beds of Harford Co., Md., and Chester Co., Pa., and the gold ores of Georgia, North Carolina, Virginia, and Canada. The gold mines of Guilford Co., N. C., are opened alongside of, and not more than ten or twelve miles distant from, the Tuscarora iron ore-belt. See figure 2 above. Both the gold and iron range continuously with the exception of one break, in New Jersey, from Quebec, in Canada, to Montgomery, in Alabama. The gold and iron-bearing rocks are: granites, gneissoid sandstones, and mica slates, all very much weathered and decomposed; and that to a depth of many

FIG. 4.


Haw River
S. Line of Rockingham Co.
N. Line of Guilford County.
28 miles.
Cath. Warren
Wid. Marg't Moore
Chilcut Bro. & McCleary.
J. W. Moore
Polly Parrish
Wid. E. Phibbs
Benaja Cr. Station
Geo. S. Kernodle and Wife
Jas. T. Witsett
Old Monroeton
Shaft
D. L. Hopkins
Chamberlain farm
Shaw House
Wm. McD. Work
J. R. Troxler
Thos. Moore
J. W. Parker
Isaac Thacker
Thos. S. McNeady
Newton H. Parker
Wm. Phibbs
HAW RIVER
Reedy Fork.
PIEDMONT RAILROAD
Arch. Bevola (Davis Tract)
Ralph Growell
Jas. T. Morehead (Thomson tract)
Jno. & Wm. Pearson and Sister.
Ben. Jordan & Wife.
Jno. A. Lambert.
Harvey Lambert.
Jas. T. Morehead (Hamburg tract)
Colston.
John Highfield
Alf. M. Witsett
Hyfield Ore Outcrop
Widow E. F. Dickey.
Reedy Fork
Wm. McMurray
Horse Pen Creek
Scale of Miles.
Geo. W. Albright
Polly Dennis
Solomon Warren.
Osborn.
Widow McCuisten.
Lewis Rayl.
15
16
17
18
19
20
21
22
23
24
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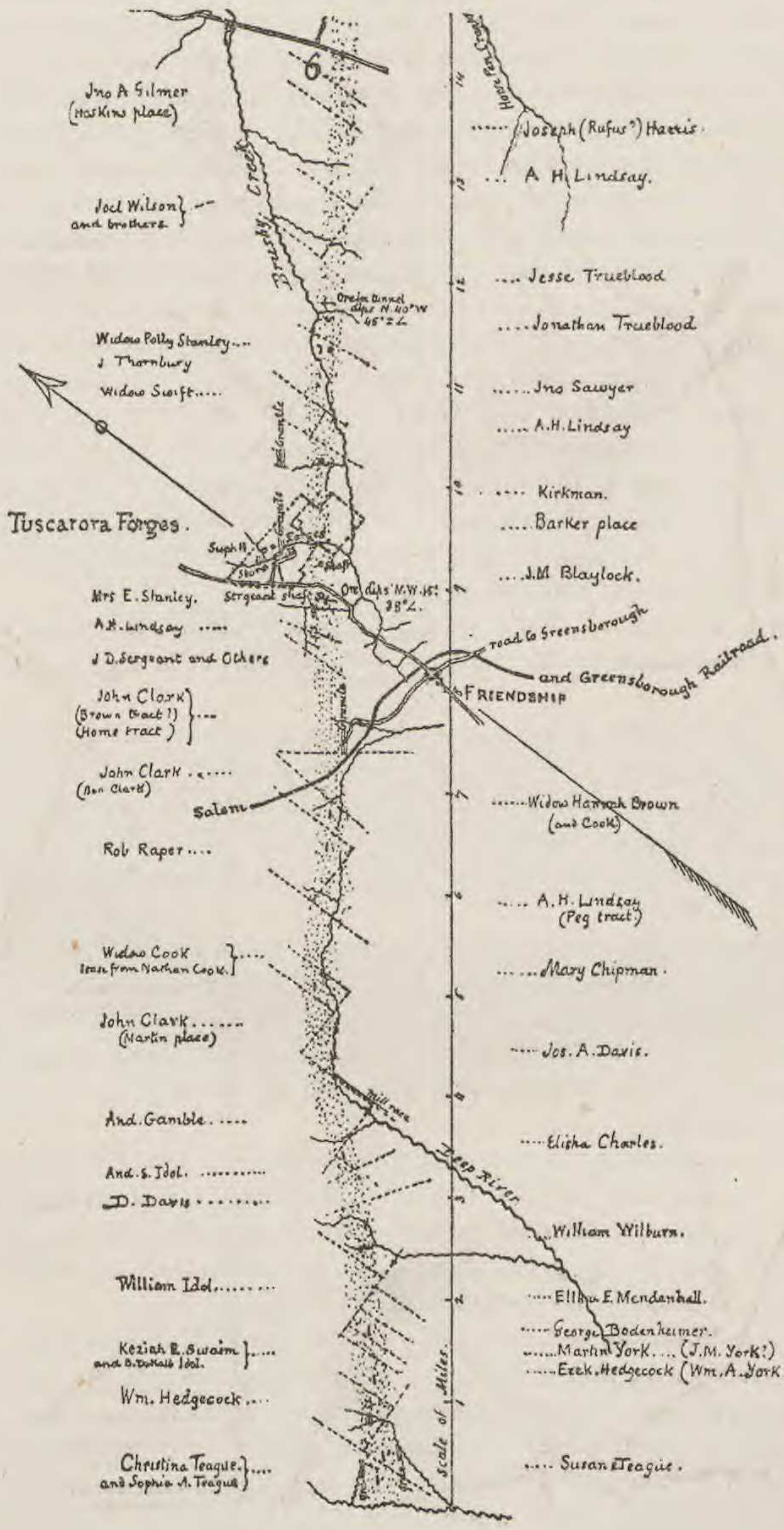
26
27

Fig. 5.


Jno A Gilmer
(Haskins place)
Joel Wilson
and brothers
Brushy Creek
Widow Polly Stanley
J. Thornbury
Widow Swift
Tuscarora Forges.
Mrs E. Stanley.
A.H. Lindsay
J D. Sergeant and Others
John Clark
(Brown tract?)
(Home tract)
John Clark
(Ben Clark)
Salem
Rob Raper
Widow Cook
John Clark
(Martin place)
And. Gamble
And. S. Idol
D. Davis
William Idol
Keziah E. Swaim
Wm. Hedgecock
Christina Teague
and Sophia A. Teague
Joseph (Rufus?) Harris
A H. Lindsay
Jesse Trueblood
Jonathan Trueblood
Jno Sawyer
A.H. Lindsay
Kirkman.
Barker place
J.M. Blaylock.
road to Greensborough
and Greensborough Railroad.
FRIENDSHIP
Widow Hannah Brown
(and Cook)
A.H. Lindsay
(Peg tract)
Mary Chipman
Jos. A. Davis.
Elisha Charles.
Deep River
William Wilburn.
Elihu E. Mendenhall.
George Bodenheimer.
Martin York. (J.M. York?)
Ezek. Hedgecock (Wm. A. York?)
Susan Teague.
Scale of Miles.

fathoms beneath the present surface. The solid granites are decomposed least; the mica slates most. All contain iron, which has been peroxidised and hydrated, in the process of decomposition of the whole formation, and dyes the country soil with a deep red tint. Or, more properly speaking, the surface of the whole country is streaked with belts of red and gray soil, following the outcrops of the more weathered and the less weathered beds. But, even in the gray belts, the solid granite, or gneiss, or sand-rock, seldom appears at the surface, although outcrops of them can here and there be found; and a number of these outcrops are designated upon the map, close to, and on each side of, the Tuscarora ore-belt outcrop. The surface of the country, therefore, is a smooth, soft, undulating plain, broken by gentle vales, the bottoms of which are never more than one hundred feet below the plain, and commonly not more than half that depth. The roads show how readily the rock soil absorbs water and dries off again. The soft, mouldered condition of all the rock strata, to depths of 50 or 100 feet, is therefore easily understood. But the rapidity with which the erosion of the land goes on is surprising. An old bridge, built a century ago, over a stream near the Quaker Meeting House, and of course several feet above the water, is now buried to a depth of 6 feet beneath the surface of its little meadow.

Two general results follow from this universal ancient rainwater decomposition of the surface of the country, to the depth of the deep valley drainage plane :—

1. All sulphur, &c., has been washed out of the ore-beds, leaving the ore remarkably pure. Whether the ore-beds, when followed down for hundreds of feet or yards into the earth, will be found to keep a notable percentage of sulphur, cannot now be known. But, whatever sulphur was originally combined with the iron, has been removed from the upper parts of the beds.

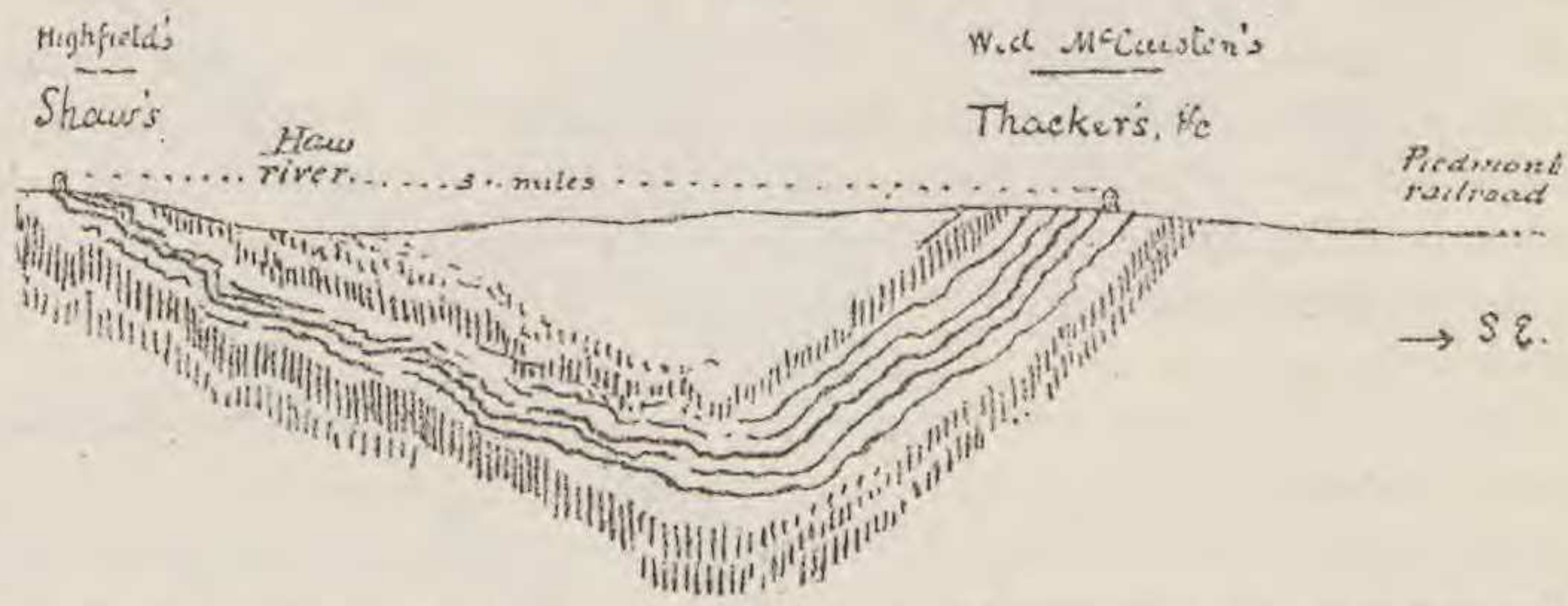
2. The decomposition of the rock strata, which inclose the ore-beds, has weakened them so that extra care must be bestowed upon all shafts and tunnels sunk or driven to win the ore, to keep them safe for mining operations. When the more solid strata, at various depths beneath the surface, are reached, mining operations will be as simple and safe as in any other region.

The hills being never more than about one hundred feet above the valley-bottoms, the ore-beds can be mined by horizontal self-draining adits, or tunnels, only at well selected points. But, seeing that the ore-beds run in straight lines for long distances, a large quantity of ore can be thus taken out, for some years to come.

The belt of outcrop of ore-bearing rocks has a uniform breadth of several hundred yards, and, I believe, a uniform dip towards the northwest, or north-northwest; although there are appearances (to be stated in detail hereafter) which would lead the casual spectator to conclude that the outcrop was double, and not single; that is, that the belt is synclinal, the ore-beds descending from the southeast side, downwards, northwestward to a certain depth, and then rising again to the surface. But the general considerations against this view are so strong, that I reject it without much hesitation; and I give my reasons further on.

The map, however, shows another ore belt running nearly parallel with the Tuscarora Forge Outcrop, and at a distance of three miles from it. This is called the Highfield, or Shaw Outcrop. Beyond the Haw River these two belts approach each other, and are believed to unite in Rockingham County. This, and other considerations, make it almost certain that the Shaw belt is the Northwest outcrop of a synclinal basin, three miles wide, and that the Tuscarora Belt is the Southeast outcrop. If so, the Tuscarora ore beds descend, with a N. W. dip, to a depth of a mile beneath the surface, and then rise again as the ore beds at Highfield and Shaw's; thus:

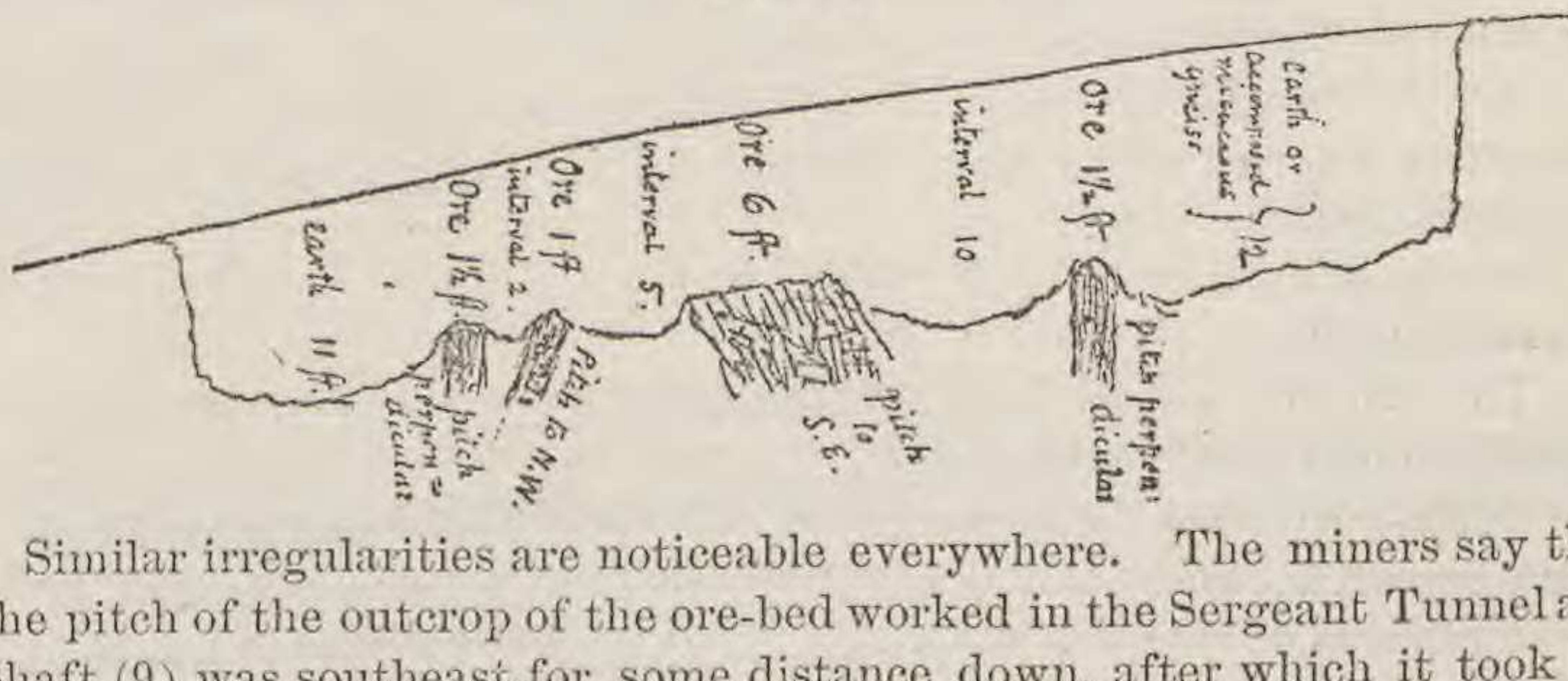
FIG. 6.



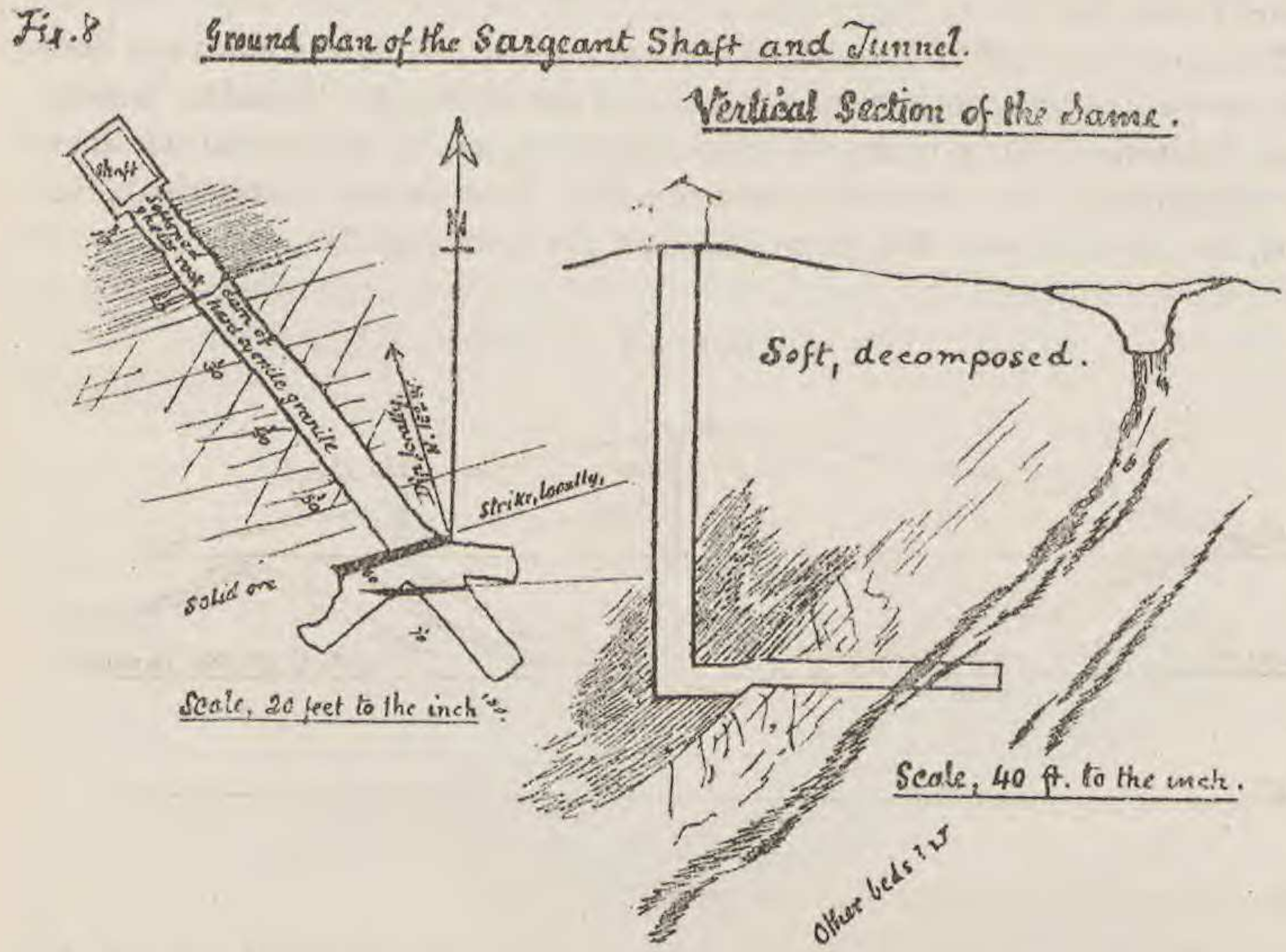
Many of the outcropping ore-beds are, to all appearance, vertical; others dip irregularly, some southeast, others northwest; some steeply, others gently. But all these are extremely local variations, confined to a few feet or yards of depth, and will not invalidate the general uniformity of northwest dip of the whole Tuscarora Belt, and southeast dip of the whole Shaw Belt.

The following section of beds on (fig. 7) the Widow McCuisten plantation (14—15 miles), in a trench cut at right angles to the outcrop, 50 feet long, and from 4 to 8 feet deep, will illustrate these irregularities :—

FIG. 7.



Similar irregularities are noticeable everywhere. The miners say that the pitch of the outcrop of the ore-bed worked in the Sergeant Tunnel and Shaft (9) was southeast for some distance down, after which it took its regular northwest dip, such as it now has in the shaft and tunnel at a depth of 100 feet. Besides which, there are in fact two beds cut in this shaft-tunnel, the smaller bed underlying the other, and with a dip which would carry the two beds together at some distance beneath the floor.



These ore-beds are not ore-veins ; for they do not cut through the rocks crosswise. They have no well defined walls ; they have no selvages ; there is no gangue-rock different from the rocks on each side ; they have, therefore, not been formed in crevices subsequently in a later age after the uptilting of the formation ; they have neither been ejected volcanically from below, nor infiltrated aqueously from above, nor secreted chemically from the wall rocks ; in a word they are not at all "veins." On the contrary they are "beds ;" beds deposited, like the rest of the rocks, in water ; deposited in the same age with the rocks which hold them ; are in fact rock-deposites highly charged with iron ; and they differ from the rest of the rocks of the formation in no respect, excepting this : that they are *more highly charged with iron.* I can best represent the facts of the case by an ideal diagram of the rocks of the ore-belt in their original horizontal position, somewhat thus :

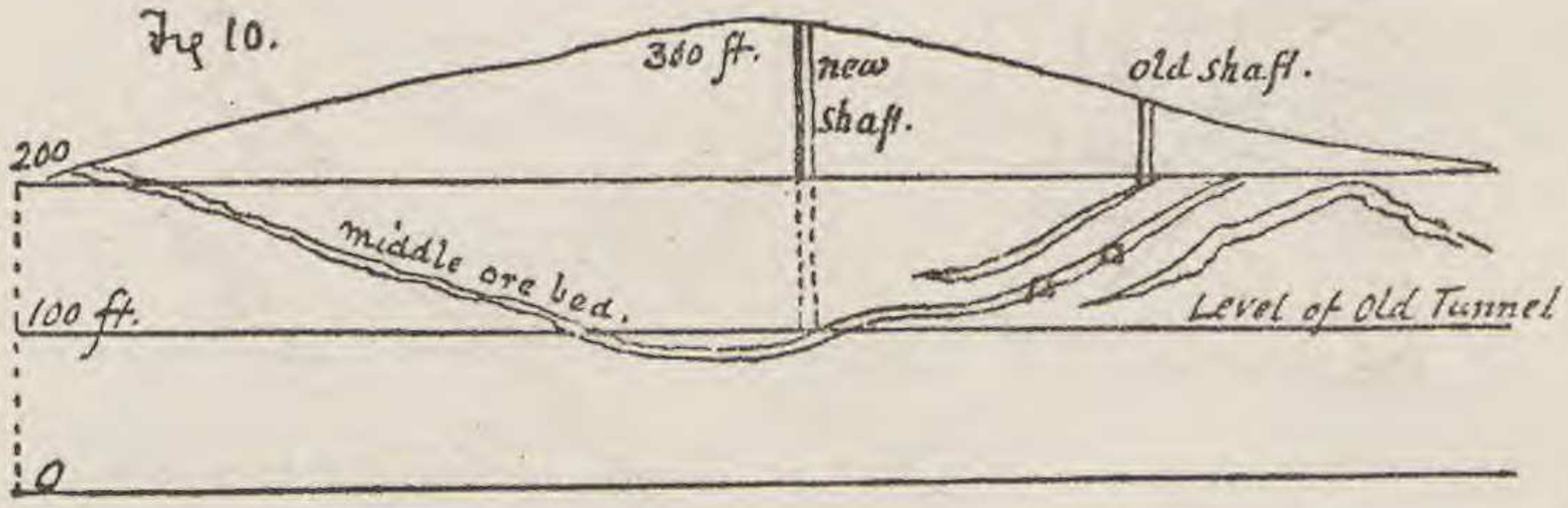
Fig. 9.

In fact all our primary (magnetic and other) iron-ore beds obey this law.

They are merely certain strata consisting more or less completely of peroxide of iron, with more or less intermixture of mud and sand, which, when crystalized, fell into the shape of feldspar, hornblende, mica, quartz, etc., etc.

To show that this is not mere theory, but actual fact, I compare here the section of magnetic iron-ore beds worked out on Durham Creek, near Easton, Pennsylvania, a map and sections of which can be seen by reference to W. Brook's part of the New Jersey Geological Report, by Prof. Cook, 1868, page 332, and given in Fig. 10.

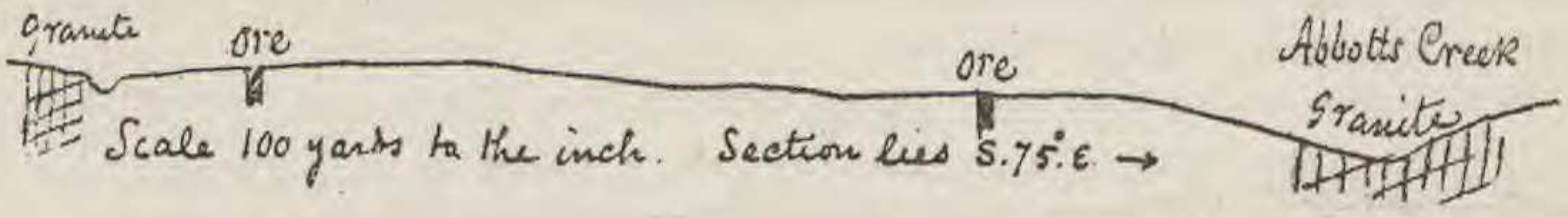
FIG. 10.



It follows then from the above mentioned facts:

1. That *the Number* of *Ore beds* in such a formation cannot be stated. A large number of rock strata will become ore-beds locally. But there will always be a particular part of the formation more generally and extensively charged with great quantities (or a high percentage) of iron than the rest. In other words, the iron of the formation as a whole is concentrated along one or more lines. This is evidently the case with the Tuscarora Ore Belt, as is shown by the almost perfect straightness of the outcrop of the Sergeant Shaft ore-bed, where its outcrop has been opened for half a mile northeast of the shaft. There are two principal beds cropping out on the Teague plantation, at the (southwest end of the belt), both vertical, and about 300 yards asunder, thus: Fig. 11.

FIG. 11.



Another instance occurs on the Trueblood plantation (12 miles), where the two ore-beds appear to be only about 200 yards apart at their outcrops, and seem to dip different ways, which I explain by reference to the false surface-dip of the Sergeant Shaft bed. The Trueblood section is as follows:

FIG. 12.

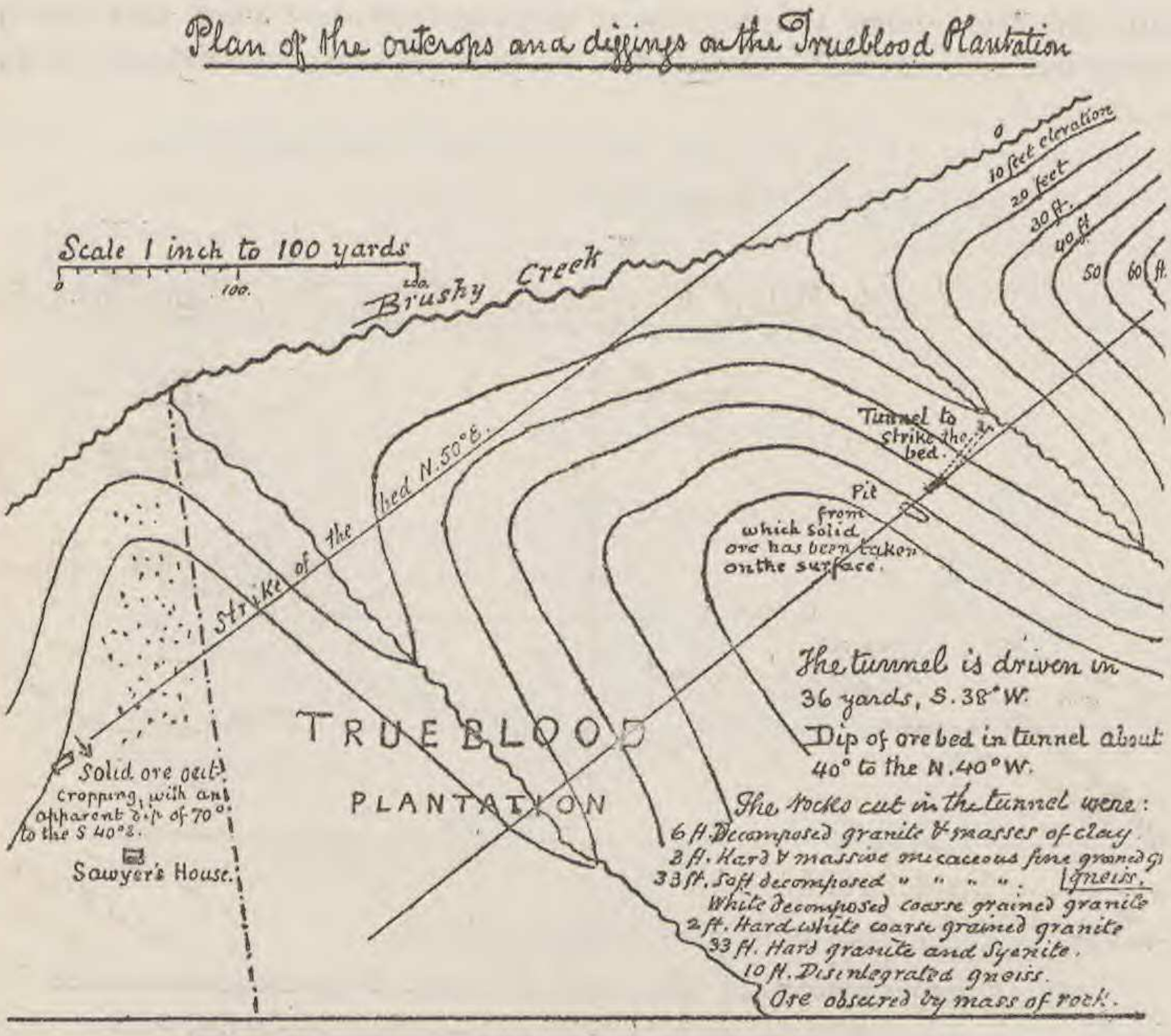
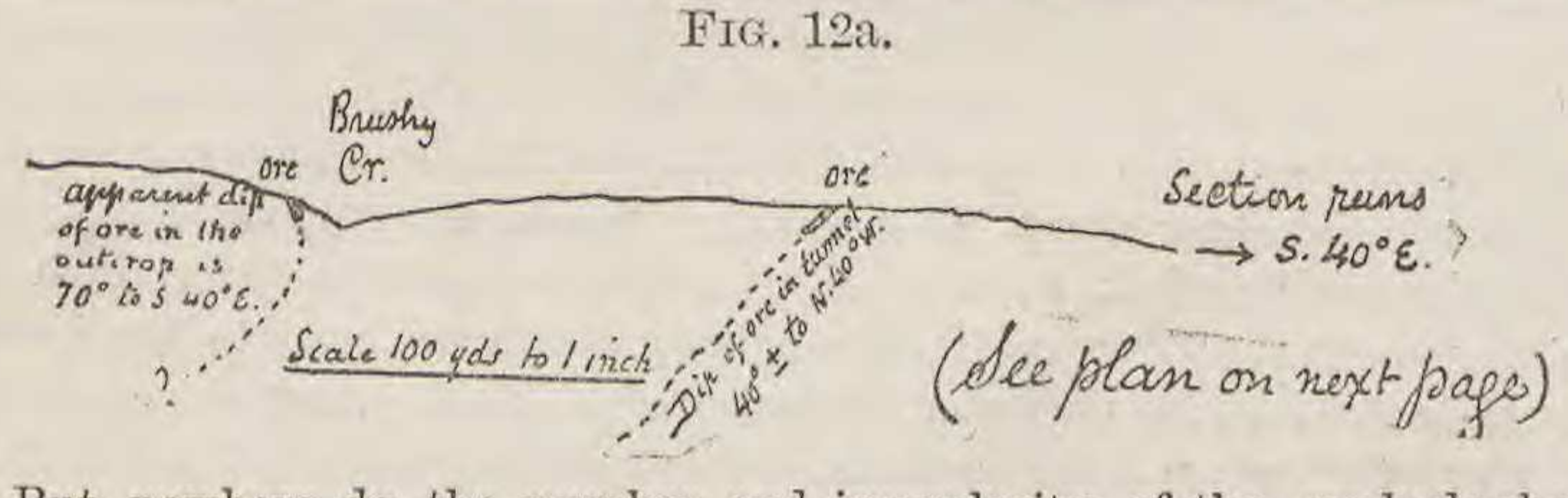


FIG. 12a.

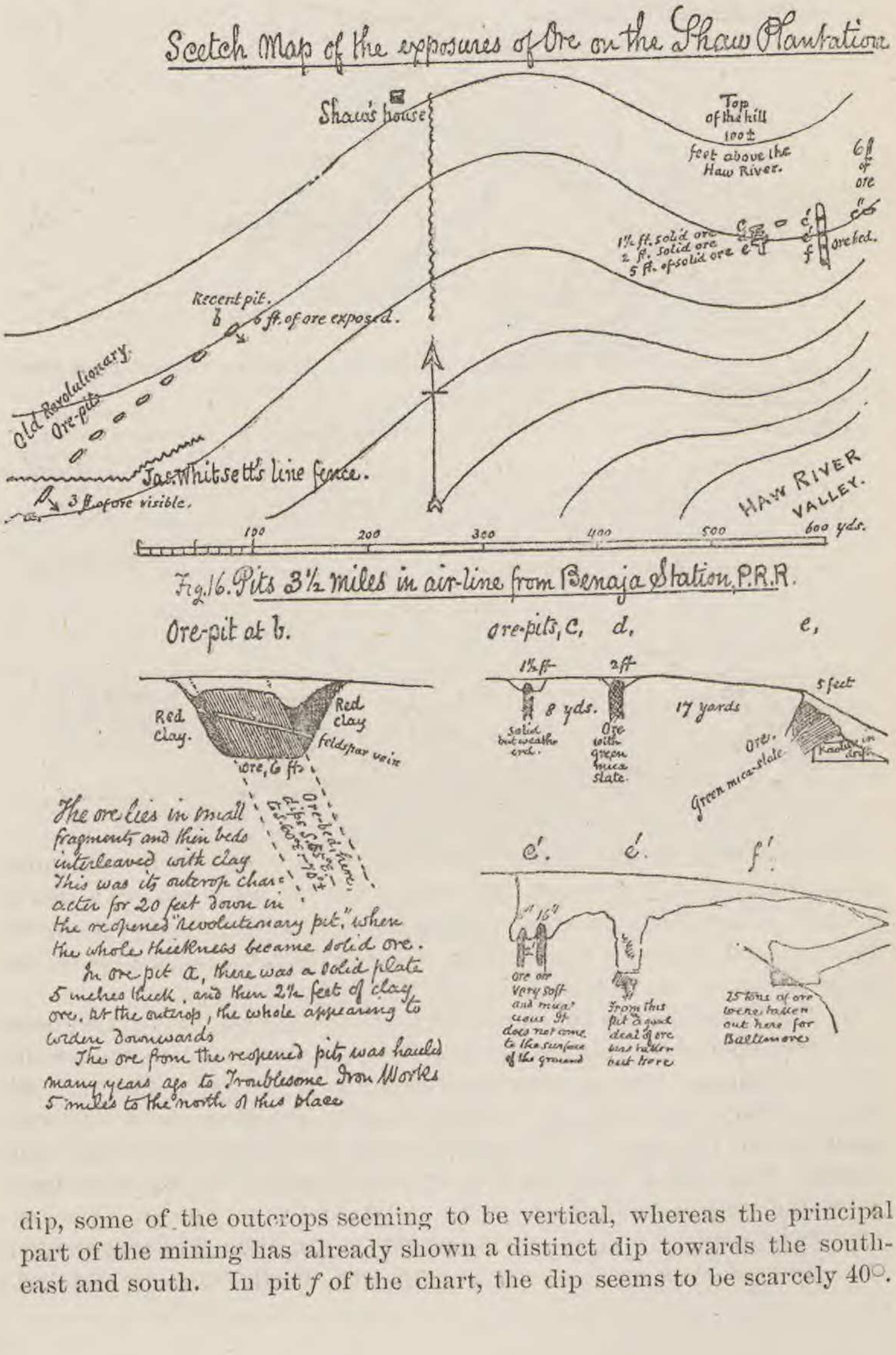


But nowhere do the number and irregularity of the ore-beds show more plainly than in the openings made on the Shaw range, and Shaw plantation, as will be seen by the plans and sections of the old revolutionary diggings, and the late shafts and trial trenches opened on that property, as given in Fig. 13, etc., further on.

On this Shaw Plantation, where three or four distinct and parallel beds have been opened, as seen in the preceding chart and diagrams, the direction of the bed changes somewhat, being N. 30° to 35° E., at the "Old Revolutionary Pits," and more nearly easterly at the openings recently made by the Company. The whole course tested amounts to over half a mile. The beds at the outcrops vary in thickness from one to six feet. At c'' the ore-bed is full 6 feet across solid ore—a very green, chloritic, mica-slate rock-ore. In this run of 800 yards, there are, *apparently, two hundred thousand tons above water-level,* in the one six-foot bed.

The ore is good. The outcrop runs along the top of a hill, about one hundred feet above the bottom of the Haw River Valley, and can be tunnelled into at that depth. There are apparent variations in the

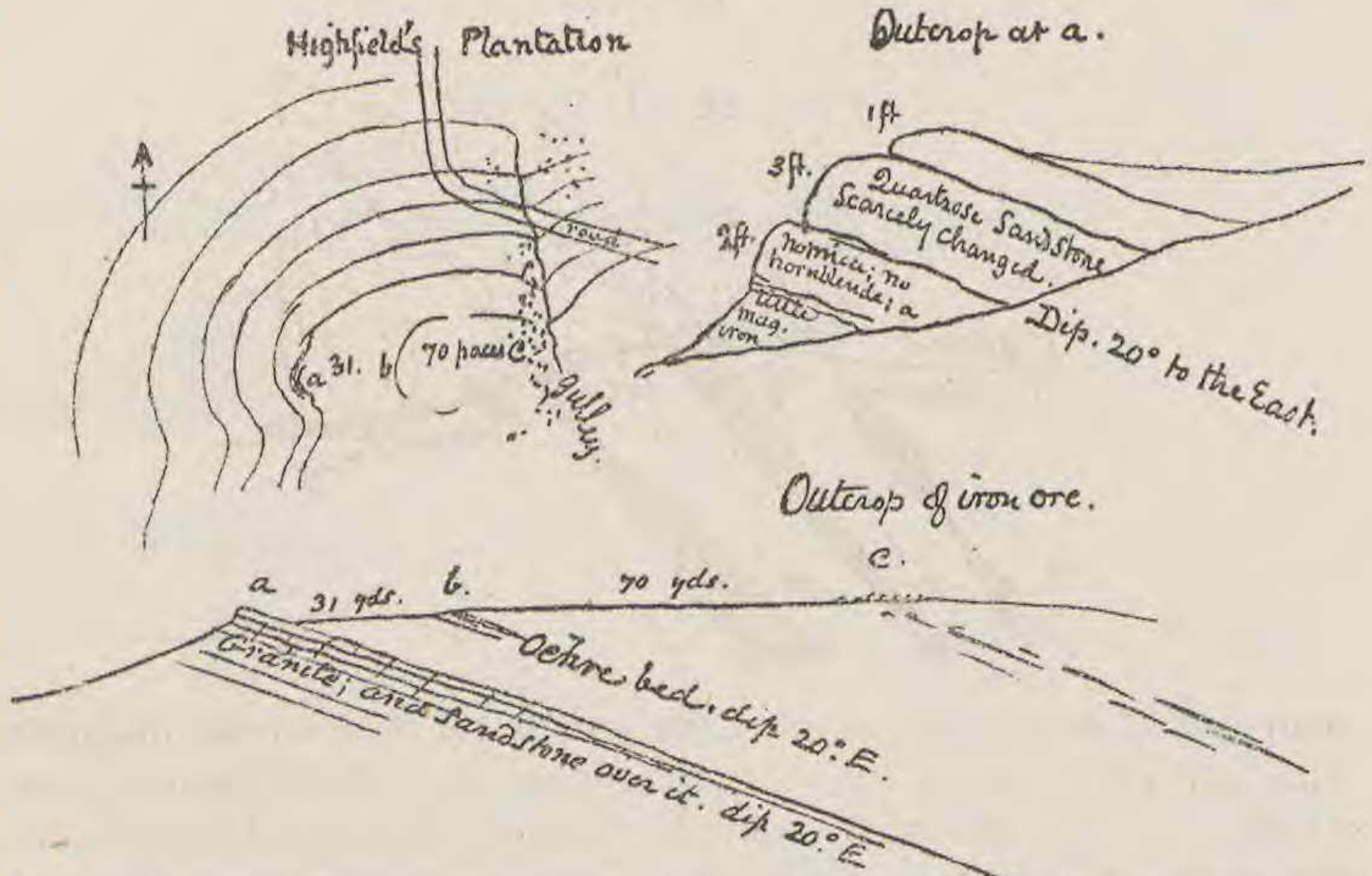
FIGS. 13, 14, 15, 16.



dip, some of the outcrops seeming to be vertical, whereas the principal part of the mining has already shown a distinct dip towards the southeast and south. In pit *f* of the chart, the dip seems to be scarcely 40°.

The Highfield outcrop shows that the ore beds lie in this Shaw range, at a much gentler angle than in the Tuscarora range ; thus :—

Fig. 14.



The distribution of pieces of ore over wide sections of the outcrop of the ore-belt, is a notable thing. Along certain narrow lines inside the belt, are to be seen multitudes of fragments lying on the ground, which have been left behind when the rest of the rock has been mouldered and washed away. And sometimes these fragments are a foot or more in diameter, although commonly smaller. Formerly, the ground was abundantly covered with them, but they were the first ore sought and used, and most of the large pieces and patches have disappeared during the war years of 1861, '2, '3 and '4.

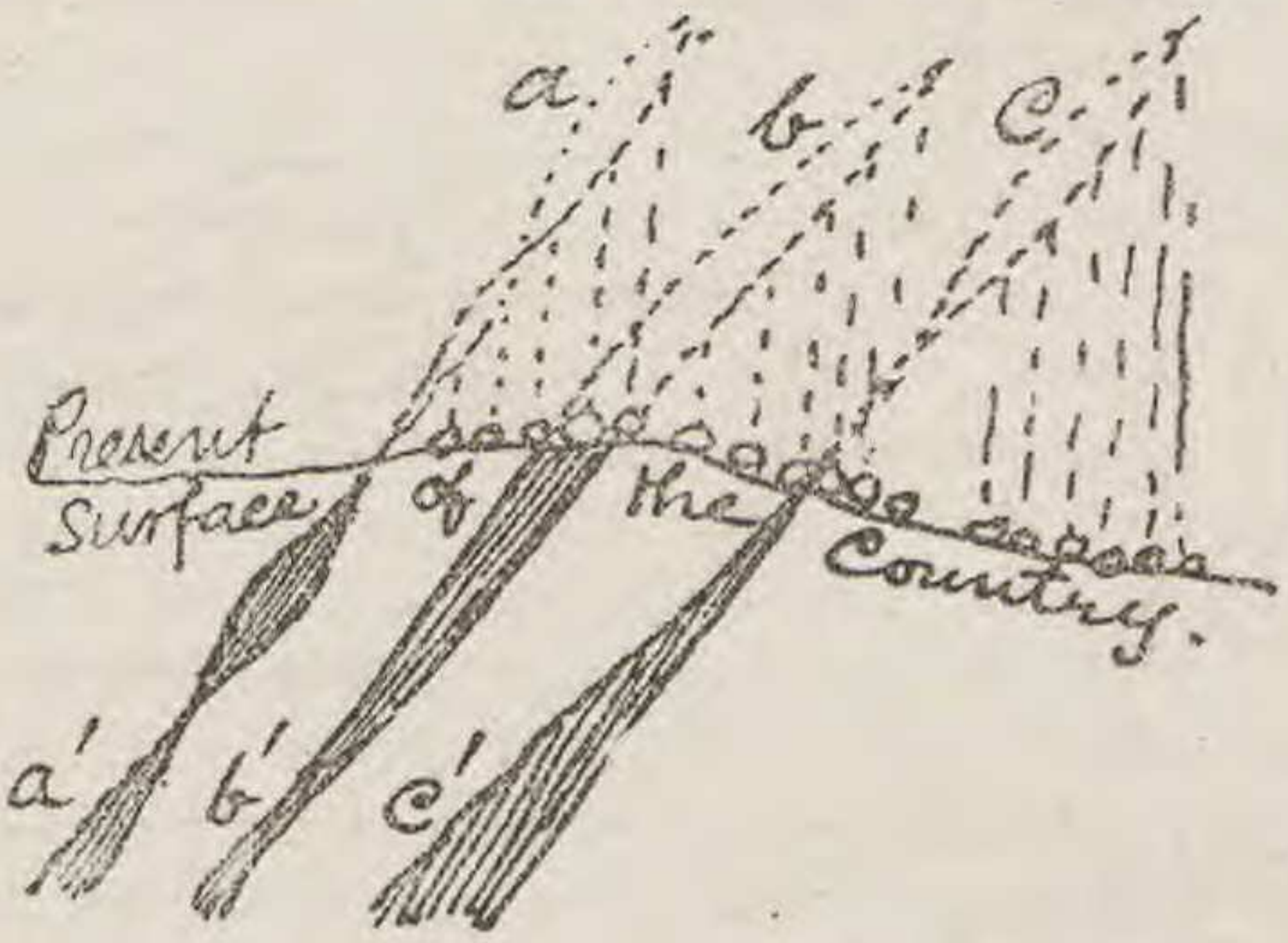
Large pieces on the surface are the best evidence we can possess (in the case of unexplored ground) that the beds are of a good size, for they have come from those portions of the beds (a, b, c, &c., in the accompanying diagram, (fig. 15), which have been destroyed in the general lowering of the surface of the country. There is no reason why the parts of the beds left under the present surface (a', b', c', &c.), should not yield as large masses as the parts a, b, c, which have been mouldered away.

2. *The Size of the Ore Beds* varies as much as their number. They consist of strings of lens-shaped masses, continually enlarging and contracting in thickness, from a few inches to six and eight feet. The principal beds may be safely estimated on an average of four feet, or 176,000 tons to the mile, with an average breasting of 60 feet above water level. It is needless to say that an equal amount would exist beneath water-level, for every sixty feet sunk on the bed.

3. *The Quality of the Ore.*—It belongs to the family of the Primary Ores. It is very similar to the New Jersey ores which are so extensively

mined for the furnaces on the Lehigh river. It is a mixture of magnetic crystals, and specular plates of sesquioxide of iron, with quartz, feldspar and mica, in a thousand varying proportions. Sometimes the bed will be

Fig. 15.



composed of heavy, tight, massive magnetite (or titaniferous magnetite), with very little quartz, &c. At other times the bed will be composed of a loose, half-decomposed mica slate, or gneiss rock, full of scattered crystals of magnetic iron.

The ore is, in fact, a decomposible gneiss rock, with a varying per centage of titaniferous magnetic and specular iron ore, sometimes forming half the mass, and sometimes constituting almost the whole of it.

The compact varieties will yield between 50 and 60 per cent. of pure iron, as in the case of the ore now being mined in the Sergeant Shaft, near the Forges. Mr. Frazer's analysis of this ore is as follows :

Magnetic oxide............73.56..........[Iron.........53.27 p. c.]
Titanic acid................13.58.............[Titanium.....6.62 p. c.]
Residuum of quartz, &c..............12.86—with a trace of sulphur.

The specimen was obtained from the tunnel, a hundred feet beneath the surface, and shows an intimate mixture of crystalline titanic ore, magnesian mica, a little hornblende, a little labradorite, and a little specular iron.

This kind is difficult to smelt in the high-stack blast-furnace ; but makes the best iron in the world when smelted in the Catalan forge ; and is of great value for the lining of puddling furnaces. It serves the same purpose as the Lake Superior ore, which is brought in large quantities to Pittsburgh, and the surrounding district of Eastern Ohio and Western Pennsylvania, for lining puddling furnaces, and to mix with poorer ores in the blast-furnaces. Formerly, in the E. Ohio Mahoning district, the mixture was : one-fourth Lake Superior, one-half coal measure ore, and one-fourth mill cinders. Since the organization of the Lake Superior Iron Ore Trade, sufficient quantities come forward to enable the iron masters to mix one-half Lake Superior. The Sharon Furnace on the Beaver river runs wholly upon Block Coal and Lake Superior Ore. The titaniferous magnetic ores of the Ottawa region, in Canada, are also brought by a long and expensive route to Pittsburgh, to mix with Pennsylvania ores. These Canada ores are of the same geological age, and of the same mineral character, as the Tuscarora ores under consideration.

Trial of the ore has been made by Mr. Nathan Rowland, at his works in Kensington, Philadelphia. Five tons were forwarded for trial as lining to puddling furnaces. Mr. Rowland expressed his opinion that it stood up three times as long as the Champlain ore, which he uses for that purpose. The difference is due to the superior compactness of titaniferous magnetite over that of pure crystalline magnetite.

I have said above, that the Tuscarora ores are essentially like those of Northern New Jersey. I referred to their age, situation, consistency, and general composition. But they have a peculiarity; they hold a notable per centage of *titanic acid.* The New Jersey ores seldom possess this property, and, in any case, only in a low degree. The Canada ores, and the ores of South Sweden, hold large quantities of titanic acid; even as much, sometimes, as between 30 and 40 per cent. A small—a very minute—quantity of titanium in pig-iron is believed to add greatly to its value, increasing its hardness and firmness, and its ability to stand wear. The Canadian ores were introduced to the Pittsburgh iron works for this end. But, seeing that almost all the titanic acid in any iron ore passes off in the slag, leaving a very small quantity to unite with the pig metal (sometimes in scattered crystals), it follows, that ores, which have an excessive quantity of titanic acid, cannot afford a high per centage of pig metal. It is much better to have an extra 20 per cent. of silex and alumina, potash or lime, in the ore, than an extra 20 per cent. of titanic acid; for these will make the ore easy to smelt, whereas the titanic acid makes it difficult to smelt; requiring a much higher heat in the stack to decompose than does oxide of iron.

There is no question that titanium in iron ore favors the production of iron peculiarly suited to conversion into steel. The English steel trade has always largely depended on Swedish iron; and I believe that the titaniferous ores of the United States (and they are far from abundant,) will become annually more and more valuable, on account of the increasing demand for the best iron for steel-making purposes. If these ores were smelted in large quantities in first-class anthracite furnaces, I do not think this particular value would appear; the small Swedish blast furnace must be used, or the Catalan forge.

Although the action of titanium upon iron in metallurgy is an obscure subject, something is known of it by actual experience.

J. H. Alexander, of Baltimore, in his report on the Manufacture of Iron, gives analyses of certain cinders, among which is one obtained in the smelting of a primary iron ore, containing, he says, 11 (eleven) per cent. titanic acid: the analysis is as follows:—

Silica	31.1	*Oxide of Titanium*	9.0
Magnesia	34.2	Protox. manganese	4.4
Lime	14.1	Protox. Iron	1.0
Alumina	8.9		

The ore, he says, was hard to smelt, and the pig-iron hard to work, but when properly made, is peculiarly adapted to the manufacture of steel.

The explanation is as follows:—Titanic acid will not combine readily with either the acid or the alkaline oxides. In every ton of ore (holding 10 per cent. of it) 320 lbs. of this neutral stuff exists, or ($1\frac{1}{2}$ tons of ore to 1 ton of iron) 330 lbs. of it in every ton of iron. If only 1-10 of this (or 33 lbs.) remains in the furnace, the gradual accumulation blocks it up. The only solvent of it are the double silicates of iron and lime, or iron and alumina and lime, or iron and potash and lime, &c. To make these double silicates, we must *waste* a good deal of iron. But the one object of the blast furnace is to *save* all the iron, and the best cinder is that which has no iron left in it, all the iron of the burden having gone down into the hearth as pure metal (with enough carbon to make it fusible). The Catalan forge, on the contrary, wastes iron, and its cinders are so rich in iron, that they are often worked over again ; hence, titanic acid is carried off, and does not obstruct the hearth. The forge fire is, therefore, the best to reduce titaniferous iron ores. But the blast furnace can smelt them also, if the heat be kept low, and some of the iron be allowed to go to waste in the cinders, to carry off the titanic acid and cinder mass. The object then, must be to make the utmost quantity of the most fusible cinder; therefore, a blast furnace running on titaniferous ores, should not be fluxed by pure limestone, pure clay, or pure sand, but with ferruginous clay, ferruginous slate, or ferruginous limestone. These fluxes will dissolve titanic acid *at a low heat.* To get gray pig iron, the cinder must be abundant ; to get white forge metal, but little flux is needed in comparison, the ore itself being wasted to form cinder. This *white iron with a large amount of carbon in it,* is just the metal from which German steel is manufactured. A high stack and a small hearth, like the Styrian furnaces, and ferruginous fluxes, are the best for titaniferous ores.

Osborne says (page 475), that Mr. Henderson writes him that the Norwegian ores are successfully used at Norton, England, on a plan invented by John Player, although they contain (by one anlaysis)

Titanic acid		40.95
Perox, iron	22.63	51.59
Protox. iron	28.96	
Magnesia	4.72	7.81
Alumina	2.11	
Silica	.42	
Protox. mang	.56	
		100.35

being smelted in small furnaces with 1000°F temperature of blast, 2 tons of coal to $2\frac{1}{2}$ tons of ore, 15 cwt. of limestone, 10 cwt. basalt rock.

"The iron becomes titanized, and is found to be exceedingly strong, and is used in Europe for armor plates, commanding *three times the price* of ordinary pig iron. The tensile strength of the resulting wrought iron, when puddled, is about $52\frac{1}{2}$ tons to the square inch. There is very little carbon in the pig-metal produced, and *being almost steel,* in puddling it requires but half the time of ordinary pig metal."

Muchat's Steel is a *titanic iron,* with the peculiarity of being sufficiently hard after being heated red hot and forged, not to require tempering, but is comparatively brittle. Its color is not white, but has a tinge of straw color light brown.

The *lighter and looser varieties* of the Tuscarora ores have a lower per centage of iron in them, but will work more kindly in the blast-furnace. I had Mr. Frazer make me an analysis of a piece of outcrop ore from the Highfield plantation. It gave: Magnetic oxide, 44.53 [metallic iron, 32.25]. These varieties make equally good iron, and iron as well adapted to the manufacture of steel.

The hard and soft varieties of ore occur often within a few hundred yards of each other; as, for example, on the Widow McCristen's plantation (14-15 miles), where the soft outcrops are seen on the hill opposite the house, and the hard ore lies in large chunks on the hill, south of the swamp. I append Dr. Genth's analysis of specimens from the two places, made at my request:

1. Massive ore from Mrs. McCristen's Plantation. The analysis was so unexpected in its character, that Dr. Genth suspected some error, and repeated it, but with the same result. The small amount of titanium shows the varying nature of the deposits. The percentage of iron is also low for this kind of ore:

Iron........................33.97 p. c.
Titanium.................... 1.60 [=2.63 p. c. titanic acid.]
Ratio of Titanium to Iron..........................1 : 21.24.

2. Soft micacious ore from the same locality. The high per centage of both iron and titanium in this ore was equally unexpected, and was very gratifying; for it will be seen from fig. 7, on page 17, that there is a total breadth of *ten feet* to this outcrop, in a space of twenty-seven. If any of the beds unite descending, the yield of ore will be great.

Iron........................43.47 p. c.
Titanium.................... 9.79 [=16.06 p. c. of titanic acid.]
Ratio of Titanium to Iron............................1 : 4.44.

It is made known by the Canadian geologists that the constituents of some of these primary ores are combined in such a way as to approximate the rock to a diorite, or green-stone trap. Now, such a rock is seen on several of the Company's leases; and especially on the Shaw, and other plantations two miles southeast of it. Sometimes the ore-bed itself become dioritic.

It will not be amiss to add other analysis of these Ores.

Ore Analysis, by F. A. Genth, in 1868.

Magnetic oxide	79.78	= iron...... 57.77
Titanic acid	12.08	
Oxide manganese	0.28	
Chrome oxide (trace of Vanadium)	0.32	
Silicic acid	0.75	
Alumina	4.62	
Magnesia	2.04	
Lime	0.13	

Ore Analysis, by J. B. Britton, June 3, 1868.

Iron (protoxide) iron........21.20 + (peroxide).......39.40		=60.60
Oxygen, with the iron in said 60.60		23.67
Mixed Sesquioxide, magnetic, &c.		84.27
{ Titanic Acid		4.95
{ Containing other insoluble matter		3.25
Alumina		4.81
Lime		0.24
Moisture		1.66

No phosphorus, and a doubtful trace of sulphur.

NOTE.—I have changed the order and wording of this analysis, to suit the others for comparison.

Ore Analysis by C. Elton Buck, Wilmington, Del., Oct. 31, 1868.

Magnetic Oxide of iron	82.68	[=Iron 59.95]
Titanic Acid	8.72	
Ox. mang........0.42. Sesq. ox. chrom......0.40		0.82
Silica	1.89	
Alumina	3.93	
Lime	0.17	
Magnesia	1.36	

Another, June, 1869.

Magnet ox. iron	81.30	[=Iron 58.52]
Titanic Acid	12.32	
Ox. Mang. and Ox. Chromium, and Sulphur		traces.
Silica	1.04	
Alumina	3.87	
Lime	0.64	
Magnesia	0.49	
No phosphorus		
Moisture and loss	0.34	

Ore Analysis, by A. A. Fesquët, Nov. 12, 1868.

Metallic iron		60.41
Titanic acid	8.65	
Sesq. ox. Chrom.........0.83 } Sesq. ox. Manganese.........0.12 }	0.95	
Silica	1.50	
Alum.	2.90	
Magnes	2.02	
Lime	0.75	

No trace of Sulphur.

A mere trace of Phosphorus.

Analysis made by pulverizing several hand specimens, and mixing them first, to obtain an average result.

Ore Analysis, by A. A. Fesquèt, July 6, 1869.

Specimen highly magnetic, and almost without moisture.

Metallic iron in combination with	57.30 }	79.14
Oxygen (calculated for peroxide)	21.84 }	
Titanic Acid		13.74
Silica	0.52	
Alumina	4.50	
Magnes	0.54	
Lime	0.72	
Sesq. Mang	0.69	

Trace of Chromium.

No sulphur ; no phosphorus.

Ochre Analysis, by A. Fesquèt, 1869.

Sesqui. ox. Iron	19.43	[containing met. iron 13.60]
Silica	34.12	
Alumina	33.21	
Water, &c., &c	13.24	

In this ochre, which forms large beds on the outcrops of the more ferruginous feldspathic rocks, one has a superior flux for any heavy burden ore, especially for a close titaniferous ore. The ochre must become a fluid double silicate, without robbing the ore, and will carry off the titanic acid in excess.

One of the constituent elements of the whole formation is Ochre, in beds of various sizes. What the exact geological relationship of these ochre beds to the magnetic ore-beds is, I do not know. But the ochre outcrops seem to be always in the immediate vicinity of the ore-beds. The largest exhibition of ochre which I saw is on the J. Somers Plantation on Brushy Creek. Here an ochre bed twenty feet thick rises, nearly vertical, out of a gully in a hillside covered with small pieces of fine compact ore.

Bar-iron Analysis, by A. A. Fesquèt, April 4, 1870.

"The samples of iron bars which you gave me to analyze have the following composition :

Metallic iron [includes what iron is combined with oxygen]	99.38
Insoluble calcined substances, [Silica, &c]	0.15
Carbon [and oxygen ?] [by difference]	0.47
Also, a trace of Titanic acid.	
	100.00

"I would judge from the nature of the samples, and former analysis, that the proportion 0.47 per cent. under head of Carbon, &c., is too considerable to be formed by Carbon alone, and comprises, very likely, carbon and oxygen. Therefore I would judge that part of the impurities is from oxide of iron, and the remainder from slag, which I have ascertained experimentally. In other words, the impurities are due to a highly basic slag, which cannot be expelled or squeezed out by the hammer and the rolls."

NOTE.—The above bars were rolled (from blooms of N. Carolina ore) by Jas. Rowland & Co., not cut and piled.

North Carolina Blooms made into Steel by the Martin's Process.

In January, 1871, Mr. A. A. Fesquét assisted at the conversion of ten tons of North Carolina blooms into steel, at Cooper & Hewitt's Works, Trenton, N. J.

The blooms were some of the first made at the Tuscarora Forge fires, rough and variable in size and quality, and weighing from 150 to 225 lbs.

Mr. Fesquét thus reports ;

The Siemens-Martin's Process consists in mixing steel scraps with pig iron. The Carbon of the pig iron reduces the iron oxidized by the flames; keeping watch, as it were, over it, and preventing the perpetually forming oxide of iron from forming a cinder with the silica of the furnace lining.

The charge being melted, it remains exposed to the flame until, and even after, all the carbon is burned off.

The exact moment is known by a series of samples being taken out, hammered and bent, hot.

If the samples be red short, Franklinite iron is added to restore enough carbon to remove the oxygen from the iron.

After one or two stirrings the metal is run into moulds.

The North Carolina blooms took the place of the steel scrap. The cast iron used was West Cumberland (English) pig, nearly free from sulphur and phosphorus, and with enough silicon and carbon to fit it for Bessemer use.

At the moment of complete decarburation a sample was taken. It was slightly red short. An analysis showed that the red-shortness was due to a minute proportion of oxide of iron and cinder, which had not been expelled because of the pasty condition of the decarburetted metal. Percentage of carbon less than 1-1000th part.

Franklinite was added; the metal became fluid, and was run into moulds.

The ingots were sound, and presented large crystals, of a clean gray color.

A sample from one was perfectly malleable, without a trace of hot or cold shortness, without a flaw, and homogeneous to all appearances. The large crystals were condensed under the hammer. The fracture was not jagged, and resembled that of cast steel of some degree of condensation and hardness.

In a word, *this* steel was malleable, homogeneous and tough, like the best steel produced in any other way.

Tried at the forge fire (by the same workman), it seemed to bear more heat for welding and hardening than will the ordinary steel (with a corresponding proportion of carbon).

Less carbon is necessary in the case of titanium steel than in the case of common steel, to arrive at the same hardness.

In the rolls, this steel manifested no difficulties, according to the testimony of Mr. Slade of the Trenton Works.

Waste: Three operations, 14,152 lbs. of metal in all; waste, 13.5 per cent., exceeding somewhat the waste when steel scraps are used; for the cinder in the blooms has to be purged off in the process, and secondly, the almost purely metallic titaniferous bloom iron is much harder to melt than scrap steel; is longer exposed therefore to the flame, and therefore wastes more. By adding pig metal this evil will find a remedy.

The peculiar qualities of this steel will no doubt be intensified when its own titaniferous pig metal is used with its titaniferous forge blooms.

A dose of Franklinite may yet be necessary. Mr. Fesquêt thinks it acts by giving up carbon. He suggests, however, that possibly it acts through manganese; but as nearly all the manganese goes off in the slag, he thinks its peculiar use is to keep the cinder fluid, and taking the iron's place in the cinder.

Stated Meeting, July 21, 1871.

Present, three members.

Mr. Chase in the Chair. Secretary, Mr. Lesley.

A photograph of Dr. O. Seidenstricker was received for the Album.

Letters of envoy were received from the Senkenburg Society, at Frankfort, the I. Akad. Vienna, and the Society at Riga.

Letters of acknowledgment were received from Dr. Bunge, of Greiswald; Herr Tunner, of Leoben; Dr. Rokitansky; the Zool. Bot. Soc., Vienna; Munich Observatory, and Chicago Academy.

A letter was read from Mr. Putnam, of Salem, the consideration of which was postponed.

Donations for the Library were received from the R. S., Tasmania; I. A., Vienna; Z. B. S., Vienna; Senk. S., Frankfort; R. Danish S.; R. Com. Geol., Italy; Capt. Settimanni; School of Mines, Paris; R. Ast., R. Geogr. and Chem. SS., London; Nature; San Fernando Observatory; Essex Institute; Mass. Hist. S., Am. Antiq. S., Camb. Mus. Com. Zool., J. H. Trumbull, Sill. Jour., Mrs. Willard, N. Y. Lyceum, Frank. Inst., Acad. N. S., Coll. Pharmacy, Med. News, Dr. Rushenberger, Isaac Lea, Peabody Inst., and Secretary Robeson, of Washington.